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PLAN FOR THE TECHNICAL DIRECTION OF THE 1962 SPRUCE BUDWORM CONTROL PROJECT IN WASHINGTON

INSECT AND DISEASE CONTROL BRANCH, DIVISION OF TIMBER MANAGEMENT
PACIFIC NORTHWEST REGION — PORTLAND, OREGON
FOREST SERVICE — U. S. DEPARTMENT OF AGRICULTURE

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By

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Technical Advisor

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PACIFIC NORTHWEST REGION U. S. FOREST SERVICE

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INTRODUCTION

A cooperative aerial spraying project will be undertaken against the spruce budworm in southern Washington in 1962. It will cover approximately 47,500 acres in Klickitat and Yakima Counties in Washington.

This plan sets forth the duties and responsibilities of technical personnel assigned to the project.

This plan has been patterned after J. M. Whiteside's "Plan for Technical Direction of the 1958 Oregon Spruce Budworm Control Project."1/

BACKGROUND

The spruce budworm is the most widely distributed and destructive defoliator in North America.2/ Before 1944, outbreaks in the Pacific Northwest usually lasted three to five years and then subsided from natural causes. Since 1944, continuing epidemics have occurred in Oregon and other western states. In 1949, extensive tree killing by the budworm was averted by timely aerial application of DDT at the rate of one pound in one gallon of #2 fuel oil per acre. Since then a total of 4.6 million acres in Oregon and Washington has been sprayed with a larval mortality of about 98 percent at a cost of $0.99 per acre.

CONTROL PLANS FOR 1962

Cooperative surveys in 1961 recorded 29,600 acres of epidemic budworm infestation in southern Washington, as compared with 20,960 acres in 1960. This increase in extent of damage was coupled with a marked increase in severity of damage. Egg mass surveys in 1961 showed a strong upward trend in the predicted feeding population for 1962.

After considering the amount of current damage and the increasing trend, the Northwest Forest Pest Action Council, at its October 27, 1961 meeting, recommended aerial spraying of the epidemic infestation and sufficient lightly infested buffer zones to control the outbreak.

The 1962 project will be administered by Washington State Department of Natural Resources. The Insect and Disease Control Branch, Division of Timber Management, U. S. Forest Service, will provide technical direction for the biological phases of the project.

1/ Whiteside, J. M. 1958. Plan for the technical direction of the 1958 Oregon spruce budworm control project. Pacific NW Forest and Range Expt. Sta. 23 pp. Multilithed.

2/ Whiteside, J. M. and Carolin, V. M. 1961. Spruce budworm in the western United States. U. S. Dept. Agric. For. Pest Leaflet 53. 8 pp., illus.

Project data are as follows:

1. Ownerships to be treated

	Acres	Percent
Private	37,500	78.9
Federal	7,000	14.8
State, County, and Municipal	3,000	63
Total	47,500	100.0

2. Probable costs (based on $1.00 per acre)

	Cost	Percent
Private share	$ 9,375	19.7
State, County, and Municipal share	21,750	45.8
Federal share	16,375	34.5
Total	$47,500	100.0

RESPONSIBILITIES FOR TECHNICAL DIRECTION

Responsibility for two important technical phases of the 1962 project will be delegated as follows:

1. Testing of Formulated Insecticide and Ingredients

The insecticide to be used on the 1962 project will contain one pound of technical grade DDT dissolved in 1.25 quarts of an auxiliary hydrocarbon solvent and diluted to one gallon with #2 fuel oil. It will be applied at the rate of one gallon per acre.

The insecticide contract will specify that fully formulated insecticide or insecticide concentrate suitable for cold blending at the airfield will be acceptable.

Arrangements will be made to have the following services performed by the U. S. Department of Agriculture, Agricultural Research Service, Entomology Research Division, Pesticide Chemicals Research Laboratory at Yakima, Washington:

a. Inspect the plant of the successful insecticide bidder and discuss the manner of insecticide formulation with the plant manager.

b. Test the ingredients to be used in formulating the insecticide or insecticide concentrate.

c. Test samples of each formulated lot of insecticide or insecticide concentrate to insure compliance with contract specifications.

A representative of the State will:

a. Witness the sampling of each lot of formulated insecticide.

b. Collect and prepare for shipment a one-pint sample.

c. Mail the sample to the Agricultural Research Service chemist at Yakima for analysis.

As soon as the analysis of DDT content has been made, the Agricultural Research Service chemist will telephone or wire the project director as to the amount of DDT per gallon in that lot. The project director will immediately notify the insecticide bidder. If the lot being sampled meets contract specifications, it will be promptly released to the transportation contractor for movement to the airfield storage tanks. If the lot is below specifications, additional DDT will be added and a second analysis will be made before release.

2. Conduct of Biological Phases

It will be the responsibility of the Insect and Disease Control Branch, Division of Timber Management, U. S. Forest Service, to provide survey data on which control recommendations can be based, participate in control planning, provide guidelines and procedures to insure the biological soundness of control operations, train technical personnel who will act as biologist, assistant biologist, and insect checkers, inspect operational procedures for entomological soundness, analyze the results of control operations, and furnish reports as needed.

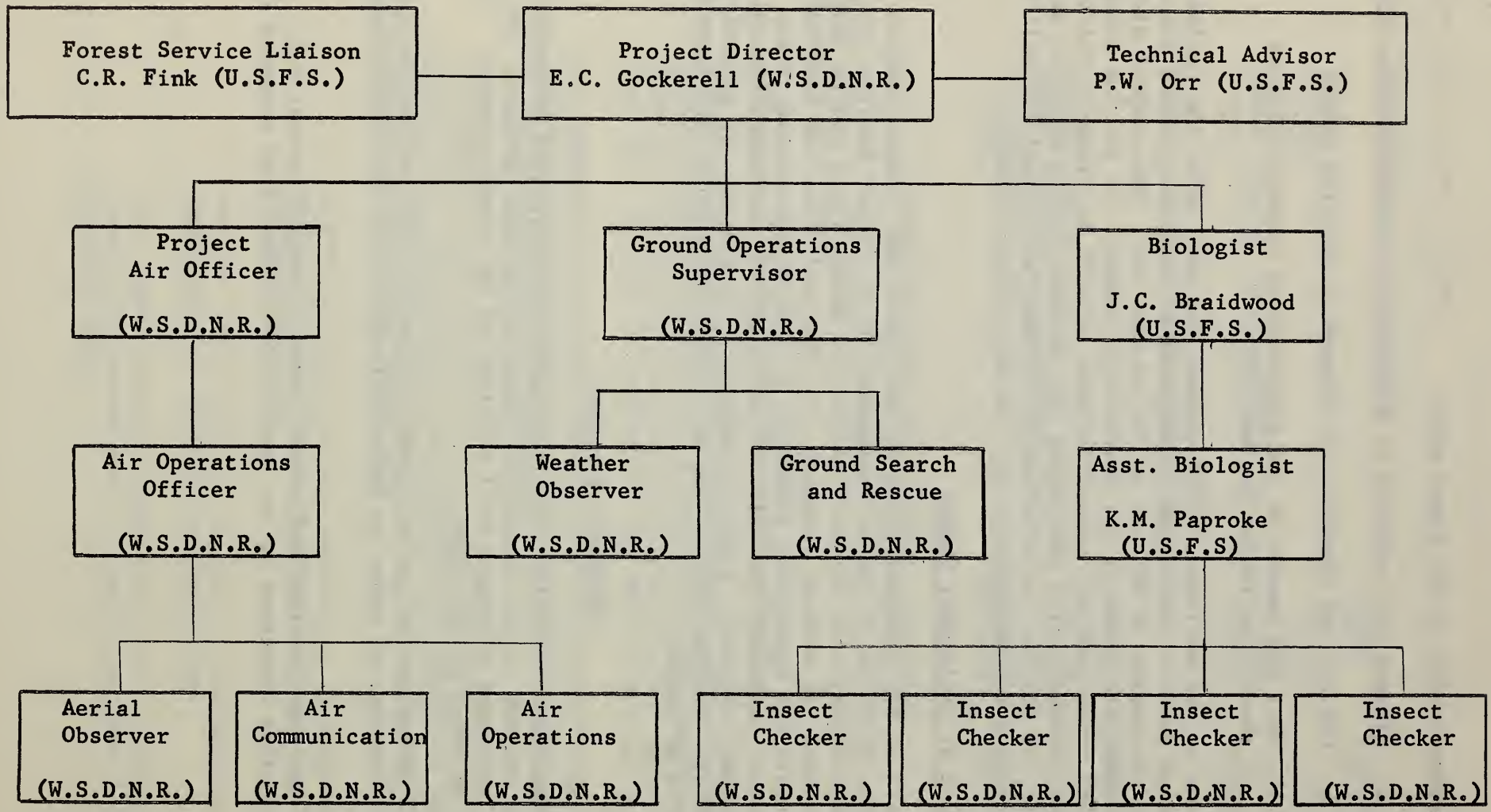
TECHNICAL PERSONNEL

A biologist, assistant biologist, and four insect checkers will be needed for the proper conduct of the biological phases of the 1962 project. The biologist and assistant biologist will be hired by the Forest Service. Insect checkers will be hired by the State.

These men will be trained by the technical advisor but will be responsible to the project director as shown in the organization chart on the following page.

All technical personnel on the 1962 spruce budworm control project will observe safe working practices as set forth in the Safety Plan prepared for the project.

TECHNICAL ORGANIZATION FOR THE 1962 SPRUCE BUDWORM CONTROL PROJECT IN WASHINGTON



Technical Advisor - Peter W. Orr will be the principal U. S. Forest Service technical representative on the project. He will be directly responsible to Benton Howard, Chief, Insect and Disease Control Branch, Division of Timber Management, U. S. Forest Service, for the field direction of the biological phases of the project. His principal duties will be:

1. To represent the contracting officer in matters concerning the biological phases of the project.

2. To work closely with project director on biological phases of the project.

3. To train, supervise, and be responsible for the work of the biologist, and to assist in training the assistant biologist and insect checkers assigned to the project.

4. To advise the project director as to the rate of larval development and the start of spraying operations. At least seven days written notice will be given to the project director as to the start of spraying operations on each unit so that planes can be ordered to the airstrip in ample time for final inspection, instructions, etc.

5. To plan and direct field studies to determine larval mortality resulting from spraying operations.

6. To prepare a final report on the technical phases of the 1962 project.

Biologist - One biologist will be needed for the 1962 project. John C. Braidwood, of the Insect and Disease Control Branch, Division of Timber Management, U. S. Forest Service, will be assigned as biologist. He will report to the technical advisor but in his absence will report directly to the project director.

The biologist should report for field duty about May 14, 1962 and will be fully trained regarding his duties by the technical advisor. The biologist will be in complete charge of all entomological aspects of the work on the project. His recommendations relative to release of spray blocks and priority of spraying will be fully respected.

The duties of the biologist will be:

1. To become thoroughly familiar with the boundaries of the project and the spray blocks within it, and the elevational zones, roads, main trails, maps, and communications. This may include an occasional aerial inspection of the project.

2. To select typical sampling spots for daily larval collections and to locate these spots on his unit map.

3. To instruct insect checkers and assistant biologist in methods of making daily larval collections.

4. To secure larval development data in spray blocks not being regularly sampled.

5. To determine rates of larval development by comparisons of daily collections with larval standards.

6. To keep accurate, neat, and detailed daily records of larval development on Form R6-5240-24, "Spruce Budworm Larval Development Record," (Appendix).

7. To locate and assist in establishment of representative mortality lines one or two days before spraying the block and to re-examine the same lines ten days after spraying. Data for each mortality line to be recorded on Form R6-5240-26, "Spruce Budworm Mortality Record," (Appendix).

8. To select the blocks and number of lines needed to sample spray distribution. Data for each line is to be recorded on Form R6-5240-28, "Spruce Budworm Spray Distribution Record," (Appendix).

9. To check larval mortality and spray coverage. The assistance of the project director and technical advisor will be obtained and the need for re-spraying and extent of the block to be re-sprayed will be determined by these three men.

10. To report daily to the project director as to the rate of larval development, start and sequence of spraying, and spraying priorities. Notices of the start, sequence, and priority of spraying will be confirmed in writing. The technical advisor will assist the biologist in setting priorities; however, the biologist will be most familiar with conditions on the blocks and his decision will be final.

11. To complete and keep current Form R6-5240-29, "Spruce Budworm Control Project Progress Chart," (Appendix).

Assistant Biologist - An assistant biologist will be needed for the 1962 project. He will be employed by the Insect and Disease Control Branch, Division of Timber Management, U. S. Forest Service, and should report for duty about May 14, 1962.

The assistant biologist will be trained and supervised by the biologist and will be directly responsible to him. The technical advisor will assist the biologist in training the assistant biologist.

The duties of the assistant biologist will be:

1. To become thoroughly familiar with the boundaries, spray blocks, roads, trails, elevational zones, etc., within the project.

2. To obtain larval development data from spot checks in spray blocks not being regularly sampled and to enter the data on Form R6-5240-24.

3. To supervise and coordinate the work of the insect checkers.

4. To supervise the establishment of spray deposit card lines by the insect checkers and to install similar lines in selected spray blocks. One spray deposit card is to be placed every five chains along a designated cruise line one day before the block is to be sprayed and retrieved one or two days after spraying. The lines will extend across the direction of spraying in each block. Record data on Form R6-5240-28.

5. To establish representative mortality lines in selected blocks one day before spraying and to re-run the same lines ten days after spraying. The data for these lines will be recorded on Form R6-5240-26.

6. To keep accurate, neat, and detailed daily records of larval development on Form R6-5240-24 and to advise the biologist daily as to this rate of development.

7. To assist, aid, and cooperate with the biologist and insect checkers at all times.

8. To confirm all communications, radio messages, telephone conversations and verbal reports in writing.

Insect Checkers - Four insect checkers will be needed for the 1962 project. These men will be employed by the Washington State Department of Natural Resources. They should report for duty about June 4, 1962.

The Insect Checkers will be trained by the Biologist who will be responsible for the over-all supervision of their work; however, they will be under the immediate supervision of the assistant biologist. The technical advisor will assist in training the insect checkers.

The duties of an insect checker will be:

1. To become thoroughly familiar with the sector of the control unit to which he is assigned--unit and spray block boundaries, roads, trails, and elevational zones.

2. To make daily collections of budworm larvae and observations on foliage development at designated points within his sector as instructed by the assistant biologist.

3. To deliver the daily collections and notes on foliage development at the end of each day to the biologist or to the assistant biologist.

4. To establish representative mortality lines in spray blocks one or two days before spraying as instructed by the assistant biologist. Record data on Form R6-5240-26.

5. To re-run the same lines ten days after spraying. Record data on Form R6-5240-26.

6. To distribute one spray deposit card every five chains along one or more designated cruise lines within a spray block one day before spraying as instructed by the assistant biologist. Record data on Form R6-5240-28.

7. To collect these same cards one or two days after spraying. Record data on Form R6-5240-28.

8. To deliver the sprayed cards to the assistant biologist the same day as collected, if possible.

DAILY COLLECTION OF LARVAL SAMPLES

The rate of larval development is determined from the daily collections of larval samples and the head width measurements of the larvae. The start and sequence of spraying operations in each block of each unit depends upon this important determination.

The procedures for making daily collections of larval samples will be as follows:

1. The biologist and assistant biologist will, when possible, determine as closely as possible the dates on which the over-wintering larvae break hibernation at various elevations. Observations should be made on key trees in various elevational zones to determine the date on which second instar larvae are first seen crawling on, or mining the needles. Since the hibernation break occurs over a period of several days, the date on which the first larvae are observed or seen mining the needles will be recorded.

2. The biologist or assistant biologist will establish representative collection points at low, medium, and high elevational zones for each insect checker. Daily collections will be made from these points up to the time the spray blocks are released for spraying; however, when all collection points are in operation, it may become necessary to alternate the day of collection from any one point. Collection points should be spaced approximately 500 feet apart in elevational zones within a spray block.

3. The biologist and assistant biologist will keep a record of all collecting points and show their locations on the project maps.

4. Daily collections will begin at the end of the needle-mining period when most of the larvae have entered the swelling buds.

5. At each collection point, 100 larvae will be collected daily. During spot checks, 50 larvae will be used as the sample from that spot. Branches to be examined will be collected with a pole pruner whenever possible. When collections are made without a pole pruner, the branches should be carefully clipped over a collecting cloth. Each bud or new growth tip is to be examined with a dissecting needle.

Live larvae in all instars and pupae are to be collected and counted on a tally register. When the required number of larvae have been tallied, the cloth or basket is to be examined and the larvae counted and added to the collection at that point.

6. Place all larvae and pupae in a vial containing 70 percent alcohol. Label as to date, collection point number, collector's name, tree host, and elevation. These data are highly important to the biologist and assistant biologist.

7. It is imperative that daily collections reach the biologist or assistant biologist at the end of each day.

RELEASE OF SPRAY BLOCKS

To be fully effective, control of the spruce budworm by aerial application of a DDT insecticide must be critically timed during a 10- to 14-day period in any one elevational zone when the larvae are exposed and vulnerable. Control is not effective when the budworm are:

a. Mining the needles as second instar larvae.

b. Protected in the tight or swollen buds during the second or third instars.

c. In the pupal or moth stages.

Therefore, aerial spraying is directed against the fourth, fifth, and sixth instars and when the current foliage is fully expanded.

The following guides will be used by the biologist in determining when a spray block is ready to be released for spraying:

1. Daily comparisons of larval head capsule widths and general larval appearance from regular collections of 100 larvae or spot collections of 50 larvae with larval standards will be the basis for determining when an entire, or part of a block, will be released for spraying. Observations on foliage development in a spray block will be used to supplement the above comparisons.

2. When the percentage of third instar larvae in a collection of 100 larvae approaches 10-15 percent, the start of spraying operations is usually 10 days away. (Quite often this percentage fluctuates around the 10 percent level for several days and then drops to 5 percent or below.) At this time, the biologist will advise the project director that spray planes should be ordered to the air-strips and that spraying will probably start on a specificed date. Record data for third instar larvae on Form R6-5240-29.

3. Blocks are usually ready for release when the new growth is fully expanded and the last daily larvae collections in that block show a combination of the following percentages on page 10.

Stage	Percent
2 instar larvae	0
3 instar larvae	1-5
4 instar larvae	40-45
5 instar larvae	45-50
6 instar larvae	1-5
Pupae	0

An example of larval development prior to the start of spraying on the 1958 Oregon project is shown on Form R6-5240-24 in the Appendix.

4. Foliage development of Douglas-fir, true firs, and Engelmann spruce must be fairly uniform throughout a spray block before its release for spraying. All bud scales must be thrown off, foliage unfurled, and new growth should be an inch or more in length.

5. When larval and foliage conditions are not uniform in an entire spray block, it will be necessary to: (1) Split the block in order to spray those portions that are ready, or (2) withold spraying until uniform conditions exist, at which time as much as 50 percent of the larvae may be in the sixth instar. The number of days that larvae have been in the sixth instar, plus day and night temperatures, determine how long a block can be held before release.

6. Release of spray blocks must adhere closely to the rate of larval development as determined by daily larval collections. As soon as a block or major portion of a block is ready for spraying, it should be released. Priority for spraying will be determined by the date the block was released. Any adjustment in spraying sequence should not be done without consultation with the biologist.

7. The biologist will determine block priorities for spraying. He will consult with the project director on portions of blocks that have to be split for prompt treatment.

8. The biologist must make daily contact with the project director to release new blocks and ascertain the progress of control operations, blocks completed, blocks partially treated, gallons sprayed and acreage covered. Contacts should be made in person whenever possible and on a schedule to be worked out by both men.

MORTALITY LINES

The goal on the 1962 project should be to sample budworm mortality in all of the spray blocks on the project. In most blocks <u>one mortality line</u> will be sufficient; however, in the larger blocks and blocks of heavy infestation, at least <u>two mortality lines</u> will be established. The technical advisor and the biologist will determine the number of lines needed in each block.

The following procedures will be followed for sampling larval mortality resulting from aerial spraying.

A. Before Spraying

1. Each biologist should determine from the project director the probable spraying pattern for the spray blocks as they are released.

2. One or two days before a block is to be sprayed, a mortality line (or lines) will be established and sampled by the biologist, or assistant biologist, and one or two insect checkers working as a crew. The line will be established perpendicular to the general spray pattern for that block. These lines can be established along trails and forest roads to facilitate checking; provided, the roads or trails are not in creek bottoms or along ridge tops. No lines will be established along main traveled roads. If a line is established and the block is not treated within five days, the line should be re-run.

3. A mortality line will consist of five sampling stations. Each station will be five chains (330 feet) apart if distances are paced and 0.2 miles apart if along roads. Each station will be tagged or marked.

4. At each station two branches, 15 inches long, will be clipped from each of five trees, making a total of ten branches at each station. A pole pruner should be used to clip these branches; however, if a collecting cloth is used, the collector should clip the branch as high as he can reach. In both cases, care must be taken not to jar the branch prior to clipping. Each 15-inch twig will be carefully examined separately for all live budworm, pupal cases, or emerged pupal cases. Record data on Form R6-5240-26. The first 100 larvae on each line are to be preserved in 70 percent alcohol as the final collection for the spray block.

5. The biologist will determine the number and percent of larvae in each instar in the final collection and record the data in the proper space on Form R6-5240-26.

6. In order to establish more than one mortality line per spray block, the crew should, at the end of the first line, offset one-half or one mile and continue across the block being sampled. If this involves sampling a portion of the block not released for spraying, the crew should reverse their original direction of travel for the next mortality line.

7. The biologist will keep an accurate record of all mortality lines on Form R6-5240-27. He will also enter dates of establishment and re-checking on Form R6-5240-29.

B. After Spraying

1. Ten days after the timber around the mortality line has been sprayed, the same line will be re-run by a two-man crew containing one man who is familiar with the mortality line.

2. At each sampling station, four branches 15 inches long will be carefully clipped from each of five trees, making a total of 20 branches at each station. Each branch will be separately examined in detail for surviving larvae, pupae, or freshly emerged pupal cases. All insect specimens collected on the entire line will be tallied on Form R6-5240-26, and preserved in 70 percent alcohol.

3. When Form R6-5240-26 has been completed, the biologist will compute spruce budworm mortality resulting from spraying. Mortality will be computed by the following formula:

$$\% \text{ Mortality} = \frac{\text{Pre-spray count} \times 2 - \text{Post-spray count}}{\text{Pre-spray count} \times 2} \times 100$$

SPRAY DEPOSIT CARDS

Spray deposit cards are used to indicate spray coverage. These cards will be used in the following manner.

1. The biologist will determine the spray blocks in which spray deposit cards will be placed. If possible, lines of these cards will be placed in every spray block. In most cases cards can be placed coincidently with mortality lines.

2. The assistant biologist will be responsible for the establishment of the card lines on the project. Most lines will be installed by the insect checkers; however, the assistant biologist will also install similar lines.

3. One or two card lines per block should be established. The lines will run perpendicular to the spray pattern for each block.

4. One spray deposit card is to be placed every five chains along a designated cruise line. An attempt should be made to extend the line across the entire block. Cards should be placed in a clear, open spot that will not be shaded from falling spray droplets. They should be tilted slightly to prevent water from standing in pools and should be held in special wire holders or weighted down with rocks to prevent them from being blown about by wind.

5. One or two days before a block is to be sprayed, a card line will be installed.

6. Within two days after the area around a card line has been sprayed, the cards will be collected by the same person installing the line.

7. Form R6-5240-29 will be completed for each spray deposit card line. These forms will be retained by the assistant biologist.

8. In cases of inadequate coverage, the biologist will be immediately notified and the need for re-spraying will be determined as outlined under Biologist, Item 9.

REPORTS

The number of reports required during the 1962 project will be kept to a minimum; however, the following are essential:

1. Technical Progress Report - The technical advisor will prepare a technical progress report on a weekly or ten-day basis. It will summarize the larval development and other technical phases of control for that period.

2. Weekly Progress Report - The biologist will submit a brief informal summary of the rate of larval development by collecting points, start and progress of spraying operations, and general climatic conditions in his unit. Form R6-5240-25, "Summary of Spruce Budworm Larval Development," (Appendix) can be used for this report. Any "beefs" should be listed. This form should be prepared on Friday night and mailed or delivered on a schedule to be arranged by the technical advisor.

3. Final Report of Entomological Aspects - A final report of the entomological aspects of the 1962 project will be prepared by the technical advisor as soon as possible after the completion of the project.

APPENDIX

NOTES FOR BIOLOGISTS AND INSECT CHECKERS

This section is designed as a guide and aid for those who, although qualified as biologists, may not be experienced in spruce budworm control projects. These few notes have been prepared in hopes that they might answer some of the questions that arise on the job and ease some of the quandries of the vital job of biologist.

The position of biologist on a spruce budworm control project is of tremendous importance. The work performed by these men is the basis essential for efficient control of the budworm by aerial spraying.

The essence of this control project is the proper timing of the release of individual spray blocks as determined by the development of spruce budworm larvae. All of the biological decisions determining the release of spray blocks for treatment are to be made by the biologist. The technical advisor will, of course, assist the biologist at all times.

A. Collecting Data

1. Larval Development - It is often impossible to sample larval development in all spray blocks. In many cases, reasonable comparisons can be made of the development on a known spray block with that on an inaccessible block. These comparisons can be made by using like elevations, direction of slope and exposure, dominant tree species, and other ecological factors. In general, the rate of larval development will occur in the following order at similar elevations: South facing, west facing, east facing, and north facing slopes. Larvae will usually develop faster at lower elevations unless in dark, cold canyons.

   In comparing larval development with foliage development, remember that after the larvae are within the opened buds, a considerable variation in growth of these two is likely to occur. This variation is directly related to temperature. Warm days and warm nights cause very rapid larval development. When these occur, larvae may develop from one instar to the next in a matter of about 24 hours or less. The appearance of large numbers of larvae in the same instar in several daily collections from the same collecting point may indicate extensive parasitism. This situation should be promptly called to the attention of the biologist and technical advisor.

2. Completion of Forms - At the time of the first collection at each regular collection point or spot check, the collector must record all the data required to complete the heading on Form R6-5240-24. This information will be promptly turned over to the biologist who will make sure all data have been secured.

All technical personnel are cautioned to be certain that all data required on the several forms to be used on the 1962 project are obtained. Each man will take time to completely fill out all form headings.

3. Spot checks - As the time for spray block releases approaches, sampling activity increases. Regular daily larval collections of 100 larvae from designated collecting points will become difficult to obtain. Consequently, spot checks of 50 larvae will usually become dominant. The biologist and assistant biologist will specify portions of blocks from which spot checks are needed. The assistant biologist should be utilized to obtain spot checks in remote or inaccessible blocks. By this time, sufficient daily collections will have been made to provide adequate comparisons for spot checks.

4. Labeling - As with forms, the importance of recording all information required and desired cannot be stressed too strongly. The clarity and neatness of labels placed in collecting vials is of vital importance to the biologist. All labels must be printed with a sharp soft pencil or India ink and pen on white paper. Ballpoint pens must not be used for making labels.

   Labels must be placed inside each collecting vial and should contain the following data:

   1. Collection point number
   2. Collector's initials
   3. Date of collection
   4. Elevation of collecting point
   5. Host tree

5. Coding - The following code will facilitate the handling of data on the 1962 project:

   Type of sample: Collecting Point = CP

   Spot Check = SC

   Mortality Line = ML

   Card Line = CL

Numbering will run consecutively for each type of sample as follows:

CP-1 = Collection Point #1

SC-1 = Spot Check #1

ML-1 = Mortality Line #1

CL-1 = Card Line #1

B. Releasing Blocks for Spraying

Spray blocks cannot always be held until all of the foliage is of uniform growth. There is too much variation in new growth by elevational zones, between individual trees of the same species, and between different species of trees. The average condition of the new growth and the percent of larvae within instars will be the keys to block releases. It is important to remember that it is the larval development that will govern the actual release of spray blocks or portions of blocks.

Just as soon as a spray block is ready for release, as indicated by larval development, give it a priority for spraying. Notify the project director by use of Form R6-5240-30.

Once a block is released for spraying, it is the responsibility of the project director to treat it as quicly as possible and by the priority established by the biologist.

C. Mortality Lines

The current success of a spruce budworm control project is determined by the over-all average percent of budworm larval mortality. The end result of the technical phase of the project will be an expression of percent mortality. Consequently, the obtaining of data for this phase cannot be over-emphasized.

Care must be taken to insure accuracy, neatness, and clarity of data taken on a mortality line. This is particularly true in recognizing empty pupal cases of the spruce budworm. The majority of pupal cases from the previous year will probably not be present when current mortality lines are run. As a point of differentiation, old pupal cases will be bleached and will have only a small amount of webbing as compared with current pupal cases. The recognition and counting of empty pupal cases of the current year is as important as the remaining larvae and pupae in determining percent mortality. An empty present year pupal case means that a pupa was formed by a larva that escaped spraying and that an adult budworm or a parasite has emerged.

D. Adequacy of Spray Deposits

The biologist will be issued one set of "Spray Deposit Index" cards with instructions for their use. In case of inadequate spray deposit, as indicated by the index, an examination of the foliage of broadleaf plants such as wild strawberry, wild rose, etc., should be made by the man picking up the spray deposit card. On these plants, the oil within the spray droplets will "burn" yellowish-brown spots wherever they land on the foliage. A film of oil on pools of water, larval webs and odor of the insecticide are also indications that some spray reached the ground. These indications should be used with extreme caution.

Observation should be made and notes taken by the collector of these indications when spray deposit cards show "misses" or very light coverage.

E. Instars

The spruce budworm passes through six (rarely seven instars) prior to pupation. Moulting is the process of transformation by which the larva change from one instar to another. Many of the daily collections will contain larvae that are in some phase of moulting. Each phase can be differentiated, which may in turn aid in separating budworm larvae by instars.

1. Prior to Moulting - During this phase, the head of the larva will appear slightly smaller in diameter than the body. In most cases the old larval skin will begin to be pushed back from the head.

2. Immediately after Moulting - The old larval skin and capsule have been shed. Usually the head will appear whitish or flesh colored and be somewhat larger than the body.

3. During Moulting - During the actual moulting, various stages between (1) and (2) will be found. In a few cases the head capsule can be found partially off the head, while in others the old larval skin will be found completely intact and moulted.

4. Width of Head Capsule - Most can be classified as to instar by appearance; however, in some borderline cases positive placement can be made only by measuring the width of the head capsule. The width of head capsule in the second through sixth instars is as follows:

Instar	Head Capsule Width (Millimeters) Average
II	.35
III	.48
IV	.76
V	1.26
VI	2.02

5. Larval Appearance by Instar - In addition to the head capsule width measurements listed on page 17, the general appearance of the larva can be used to determine the correct instar of the budworm.

Instar	Larval Appearance
I	Body light green. Head capsule light brown.
II	Body yellow-orange. Head capsule dark brown. Thoracic shield dark brown and entire. Length 4mm.
III	Body orange-brown. Head capsule dark brown to black. Prothoracic shield black: rear margin slightly undulate and shield brown. Length 5-7 mm.
IV	Body orange-brown. Head capsule black. Prothoracic shield black with slight medial notch on rear margin. Setal areas small and pale. Anal shield ivory with brown pattern. Length 6-10 mm.
V	Body olive-brown with orange lateral stripes. Head capsule chestnut brown with black triangular markings at base. Prothoracic shield black; rear medial notch goes half way through the shield. Anal shield tan. Setal areas conspicuous ivory color. Length 10-16 mm.
VI	Body olive brown, but color variable. Head capsule chestnut-brown to tan. Prothoracic shield divided in the middle and collar-like. Setal areas distinctly whitish. Anal shield tan. Length 16-30 mm.

F. Insect Identification

Not all defoliating insects collected by the technical personnel will be spruce budworm. A set of ten colored drawings will be provided to assist the biologist and assistant biologist in separating the more common insect species associated with the spruce budworm that are likely to be encountered on the project.

EQUIPMENT FOR TECHNICAL PERSONNEL

The following list of equipment and supplies on page 20 will be furnished by the Insect and Disease Control Branch for the biologist, assistant biologist, and/or insect checker as shown.

A. Items Furnished by Insect and Disease Control Branch

1. Laboratory Equipment	Biologist	Assistant Biologist	Insect Checker	Total
Alcohol, Ethyl (95%)	1 gal.	1 gal.		2 gal.
Binocular Microscope	1	1		2
Desk Lamp (1-Fluorescent)	1	1		2
Dissecting Needles	2	2		2
Extension Cords	1	1		2
Eyedroppers	2	2	1	8
Forceps	3	3	1	10
Forceps, Jeweler's	1	1		2
Glass Vials and Corks:				
24 x 95 mm.	½ gross	1 gross		1½ gross
10 x 75 mm.	½ gross	½ gross		1 gross
9 x 53 mm.	1 gross	1 gross		2 gross
Graduate (250 ml.)	1			1
Larval Standards	1	1		2
Lens Tissue	1	1		2 pkg.
Lens Brush, Camel Hair	1	1		2 pkg.
Magnifier	1			1
Microscope Lamp	1			1
Microscope Grid	1			1
Petri Dish	3	3		6
Tatum Holder, 8 x 10	1	1	1	6
Tatum Holder, 5 x 8	1	1		2
Vial Racks:				
24 x 95 mm.	2	2		4
10 x 75 mm.	1	1		2
9 x 53 mm.	1	1		2
Watch Glasses (Syracuse)	2	2		4
Wash Bottle (1 liter)	1			1
Wash Bottle (500 ml.)	1	1		2

2. Field Equipment				
Altimeter	1	1	1	6
Binoculars	1			1
Bag, canvas carrying		1	1	5
Canteen, 1 gal.	1	1	1	2
Collecting Cloth, muslin	1	1	1	6
Collecting Boxes	1	1	1	6
Compass, Pocket	1	1	1	6
Dissecting Needle	2	2	2	12
First Aid Kits	1	1		2
Flagging, Plastic	2 rolls	2 rolls	1 roll	8 rolls
Hand Lens (10X)	1	1		2
Hard Hats	1	1		2
Pruners, Hand	1	1	1	6
Pruners, Pole		1	1	5

A. Items Furnished by Insect and Disease Control Branch (Continued)

2. Field Equipment	Biologist	Assistant Biologist	Insect Checker	Total
Spray Paint	10	10	4	36
Tally Register	1	1	1	6
Tatum Holder, 8 x 10			1	4
Tree Markers, Shipping Tags	100	100	100	600
Vehicle, Sedan	1			1
Vehicle, Jeep		1		1
3. Supplies				
Control Plan	1	1	1	6
Technical Plan	1	1	1	6
Control Area Map:				
2" per mile	1	1	1	6
1" per mile	1	1	1	6
½" per mile	1	1	1	6
Envelopes (Franked)	50			50
Form FS 44 (Purchase Order)	1 book			1 book
Form 64 (Office Memo)	1 pad	1 pad	1 pad	6 pads
Form R6-5240-24	25	25		50
Form R6-5240-25	25	25		50
Form R6-5240-26	25	25		50
Form R6-5240-27	25	25		50
Form R6-5240-28	25	25		50
Form R6-5240-29	10	10		20
Form R6-5240-30	25	25		50
Larval Diagrams	1			1 book
Notebook, 3 x 5	2	2	2	12
Notebook, 5 x 8	1	1		2
Office Box	1	1		2
Paper, Carbon	1 box			1 box
Paper Clips	1 box	1 box		2 boxes
Pen, Ballpoint	1	1	1	6
Pencils, Mechanical	2	2	3	16
Scratch Pads	2	2		4
Spray Deposit Cards	500			500
Spray Deposit Index	1	1		2
Stapler (Hand)	1			1
Tape, Scotch	1 roll	1 roll		2 rolls
Tape, Masking	1 roll			1 roll
USGS Quadrangle Sheets	1 set	1 set		2 sets

B. Items Furnished by Washington Department of Natural Resources

1. Field Equipment	Biologist	Assistant Biologist	Insect Checker	Total
Vehicle (Jeep)			2	2
Plan of Operations	1	1	1	6

SPRUCE BUDWORM LARVAL DEVELOPMENT RECORD

Location _____ Spray Block _____ Collection Point _____

Twn. _____ Rge. _____ Section _____

Elevation _____ Exposure _____

Block Released 7/2/58 Spraying Begun 7/4/58 Collector _____

Collection date	Tree sp.	Larval Instars II No.	II %	III No.	III %	IV No.	IV %	V No.	V %	VI No.	VI %	Pupae No.	Pupae %	Total No.
7/2	DF	—	—	—	—	19	34	35	63	2	3	—	—	56
7/3	DF	—	—	—	—	16	27	40	68	3	5	—	—	59

Form R6-5240-24 (5/62)

SUMMARY OF SPRUCE BUDWORM LARVAL DEVELOPMENT

Project_____ Biologist_____ Date_____

Location	Spray block	Coll. point	Collector	(% of Daily Collections)					
				II	III	IV	V	VI	Pupae

Form R6-5240-25 (5/62)

SPRUCE BUDWORM MORTALITY RECORD

Project_____ Spray Block_____ Line No._____

Location_____ Direction Run_____

Elevation-Start_____ Finish_____ Collector_____

Date Block Released_____ Date(s) Block Sprayed_____ Pilot_____ Plane_____

Before Spraying 1/

Date Established_____ Collector_____

After Spraying 2/

Date Re-examined_____ Collector_____

Plot No.	Dist. next plot	Tree sp.	Tree No.	Spruce Budworm Count Each 15" twig Larvae	Pupae	Twig lot	Spruce Budworm Count Each 15" twig Larvae	Pupae	New emer.	Twig lot
1			1							
			2							
			3							
			4							
			5							
2			1							
			2							
			3							
			4							
			5							
3			1							
			2							
			3							
			4							
			5							
4			1							
			2							
			3							
			4							
			5							
5			1							
			2							
			3							
			4							
			5							

1/ Two 15" branches from each of 5 trees

2/ Four 15" branches from each 5 trees

Last larval development before spraying

	2	3	4	5	6	pupae	total
No.							
%							

Stage of budworm survivors

	3	4	5	6	pupae	total
No.						
%						

Form R6-5240-26 (5/62)

SUMMARY OF SPRUCE BUDWORM MORTALITY

Project_____ Biologist_____ Date_____

Spray Block No.	Line No.	Before Spraying					After Spraying					
		Date Est.	Collec-tors	No. Larvae	No. Pupae	Total	Date Re-Ex.	Collec-tors	No. Larvae	No. Pupae	No. Emer. Pupae	Total

Form R6-5240-27 (5/62)

SPRUCE BUDWORM SPRAY DISTRIBUTION RECORD

Control Project_____ Spray Block No._____ Line No._____

T.____ R.____ Sec._____ Pilot_____ Plane_____ Checker_____

Local landmark_____

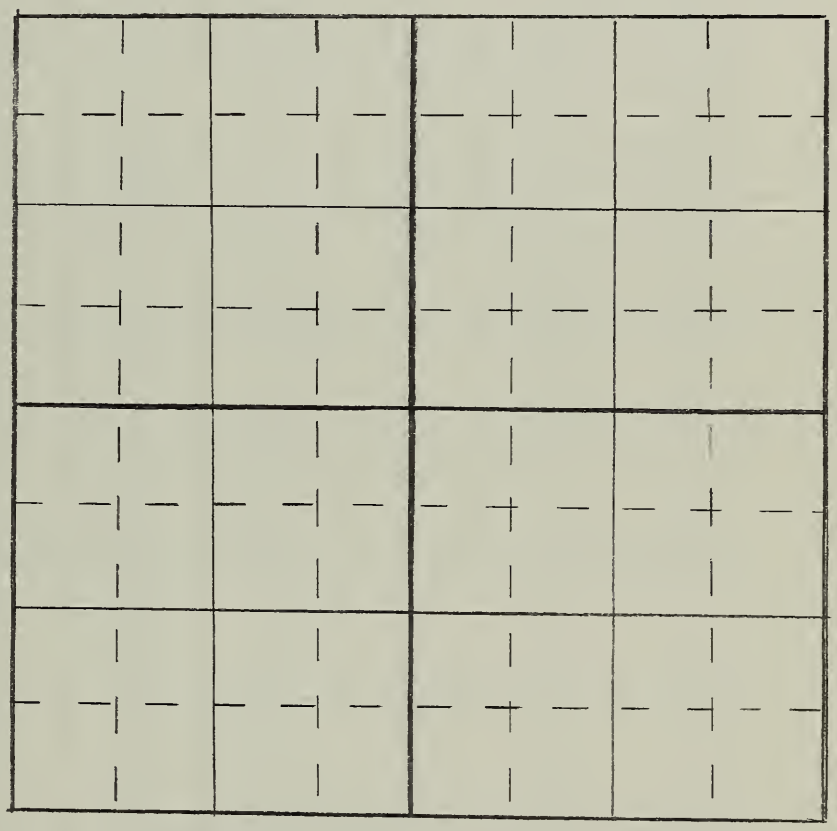
Line starts at_____ on_____ azimuth

Date laid out_____ Time laid out_____ Date picked up_____ Time picked up_____

Spray Deposit

Sta.	G/A
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

SKETCH



Scale_____per mile

Remarks: _____

Form R6-5240-28 (5/62)

SPRUCE BUDWORM CONTROL PROJECT PROGRESS CHART

Spray Block	Elev.	Acres	Coll. Pts. Est.	Spray in 10 days	Mort. Lines Est.	Block Released	Spray Cards Laid Out	Spraying		Pilot	Plane	Spray Cards Picked Up	Mort. Line Re-run	Mortality %
								Begun	Finished					
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														

Form R6-5240-29 (5/62)

SPRUCE BUDWORM CONTROL PROJECT

Notification of Release of Spray Blocks

Date: _____

To: _____, Project Director

From: _____, Biologist

The following described spray blocks will be ready for spraying on _____ (day) _____ (date) in the priority and portion listed below:

Priority	Block no.	Total acres	Portion released	Remarks
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Total acreage released by this notice: _____ acres

Unless otherwise stated, the lower elevations of each block should be sprayed first if the period of spraying each block exeeds one day.

Approved: _____
Biologist

If this is a verification of a release by earlier communication, such release was given by me on _____ (date) by _____ communication.

1 copy each to: Project Director
U. S. Forest Service (Div. Timber Mgmt.)
Biologist

Form R6-5240-30 (5/62)